20. A device manufacturing method, including a process for transferring a device pattern onto a wafer by use of a projection exposure apparatus as recited in Claim 19.

REMARKS

Applicant requests favorable reconsideration and allowance of the subject application in view of the preceding amendments and the following remarks.

To place the subject application in better form, the specification has been amended to correct minor informalities. No new matter has been added by these changes.

Claims 1-20 are presented for consideration. Claims 1, 2, 11 and 12 are independent.

Without conceding the propriety of the rejections set forth in the above-noted Office Action and solely to advance prosecution, Applicant has amended Claims 1-5 and 11-15 to clarify the features of the subject invention. Support for these changes can be found in the original application, as filed. Therefore, no new matter has been added.

Applicant requests favorable reconsideration and withdrawal of the rejections set forth in the above-noted Office Action.

Claims 1, 3, 4, 11, 13 and 14 were rejected under 35 U.S.C. §112, second paragraph, as being indefinite. The Examiner objected to specific recitations in these claims. To expedite prosecution, Applicant has amended these claims in light of the Examiner's comments. Applicant submits that these changes overcome this rejection. Such favorable indication as requested.

Turning now to the art rejections, Claims 1-3, 7, 8, 11-13, 17, and 18 were rejected under 35 U.S.C. §102 as being anticipated by U.S. Patent No. 5,648,871 to Okuyama et

al. Claims 1-20 were rejected under 35 U.S.C. §103 as being unpatentable over the published European Patent Application No. 0 660 169 (The European document) in view of U.S. Patent No. 5,490,013 to Shimizu, et al. Applicant submits that the cited art, whether taken individually or in combination, does not teach or suggest many features of the present invention as previously recited in Claims 1-20. Therefore, these rejections are respectfully traversed.

In one aspect of the invention, independent Claim 1 recites an aberration changing optical system for changing an aberration. The optical system includes an optical element having at least one of a cylindrical surface and a toric surface, the optical element being rotatable about and tiltable to an optical axis of the optical system.

In another aspect of the invention, independent Claim 2 recites an aberration changing optical system for changing an aberration. The optical system includes an optical element having different refracting powers in two orthogonal directions or having a refracting power only in one direction, the optical element being rotatable about and tiltable to an optical axis of the optical system.

In still another aspect of the invention, independent Claim 11 recites an optical element for a projection exposure apparatus. The optical element has at least one of a cylindrical surface and a toric surface, the optical element being inclined with respect to an optical axis.

In yet in another aspect of the invention, independent Claim 12 recites an optical system for a projection exposure apparatus. The optical system includes an optical element having different refracting powers in two orthogonal directions or having a refracting power only in one direction, the optical element being inclined with respect to an optical axis.

Applicant submits that the cited art does not teach or suggest such features of the present invention, as recited in the independent claims.

In the Okuyama, et al. patent, the anamorphic optical system 70 is tiltable, by rotating it at the zero point and around the rotational axis, which is orthogonal to the optical axis. That system, however, does not rotate around the optical axis or is not inclined with respect to an optical axis, as in the present invention recited in the independent claims. The Examiner takes the position that the optical system 70 in the Okuyama, et al. patent is rotatable around the optical axis. Applicant respectfully disagree with this reading of the Okuyama, et al. patent, since figure 21 and the discussion at column 7, lines 20-28 of the Okuyama, et al. patent set forth that the optical system 70 merely rotates about the rotational axis which is orthogonal to the optical axis.

Still further, the Okuyama, et al. patent relates to an optical system in a display device of a projection type. The present invention, as recited in Claims 11-20, however, is directed to an optical system in a projection exposure apparatus. Therefore, Applicant submits that the Okuyama, et al. patent is remote from the present invention recited in these claims.

For the reasons advance above, Applicant submits that the Okuyama, et al. patent does not teach of suggest the salient features of Applicant is present invention, as recited in the independent claims.

Applicant likewise submits that the cited combination of art does not teach or suggest such features of the present invention.

The Examiner takes the position that cylindrical lenses 1 and 2 of the European document would be tiltable an rotatable about and optical axis in view of the teachings of the Shimizu, et al. patent. Applicant notes, however, that Shimizu, et al. patent teaches tilting a transparent parallel plate with respect to an optical axis. That patent, however, does not teach or suggest teaching or rotating a lens with respect to an optical axis. Therefore, that patent likewise does not teach or suggest tilting or rotating a cylindrical lens with respect to an optical axis in the

manner of the present invention recited in the independent claims. Accordingly, Applicant submits that the proposed combination of the European document and the Shimizu, et al. patent does not teach or suggest the salient features of Applicant is present invention, as recited in the independent claims.

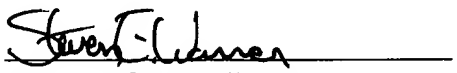
For the foregoing reasons, Applicant submits that the present invention, as recited in independent Claims 1, 2, 11 and 12 is patentably defined over the cited art, whether that art is taken individually or in combination.

Dependent Claims 3-10 and 13-20 also should be deemed allowable, in their own right, for defining other patentable features of the present invention in addition to those recited in their respective independent claims. Further individual consideration of these dependent claims as requested.

Applicant submits that the instant application is in condition for allowance. Favorable reconsideration, withdrawal of the rejections set forth in the above-noted Office Action and an early Notice of Allowance are requested.

Applicant's undersigned attorney may be reached in our Washington, D.C. office by telephone at (202) 530-1010. All correspondence should continue to be directed to our below-listed address.

Respectfully submitted,



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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE SPECIFICATION

Please substitute the following paragraph for the paragraph starting at page 1, line 10 and ending at line 27.

--The need for higher density of a semiconductor device such as an IC or LSI has been increased more and more. In reduction type projection exposure apparatuses (steppers) wherein an image of a circuit pattern of a mask (reticle) is formed on a photosensitive substrate (wafer) through a projection optical system and the photosensitive substrate is exposed in accordance with a step-and-repeat method, or in reduction type projection exposure apparatuses (scanners) wherein a photosensitive substrate is exposed with a circuit pattern of a mask (reticle) in accordance with a step-and-scan method, many improvements have been attempted with [in] respect to the resolution of a projection optical system and the precision of pattern registration for repeated projection exposures, printing different patterns upon the same region, to thereby meet the requirements of higher density integration.--

Please substitute the following paragraph for the paragraph starting at page 3, line 2 and ending at line 16.

--Japanese Laid-Open Patent Application, Laid-Open No. 121816/1989, shows an example of fine adjustment of aberration of a projection system, wherein an aberration adjusting optical system comprising a light transmissive parallel flat plate is inserted onto an optical path

between an image side of a projection optical system, having telecentricity, and an imaging plane thereof, to thereby adjust spherical aberration and on-axis coma [comma] aberration of the projection optical system. In this structure, the spherical aberration of the projection optical system can be adjusted by changing the thickness of the parallel flat plate, while the on-axis coma [comma] aberration can be adjusted by tilting the parallel flat plate.

Please substitute the following paragraph for the paragraph starting at page 3, line 17 and ending at page 4, line 10.

--Japanese Laid-Open Patent Application, Laid-Open No. 27743/1998, shows another example of fine adjustment of aberration of a projection system, wherein an aberration adjusting optical system is provided on an optical path between an image side of a projection optical system, having telecentricity, and an imaging plane thereof. The aberration adjusting optical system comprises two parallel flat plates having the same refractive index and the same thickness and being inclined with respect to an optical axis in opposite directions and by the same angle, means for changing the tilt angles of these two transparent flat plates in opposite directions and by the same amount, means for rotating the whole adjusting optical system integrally about the optical axis of the projection optical system, and means for tilting the whole adjusting optical system integrally in a desired direction. This aberration adjusting optical system adjusts spherical aberration, on-axis astigmatism, and on-axis coma [comma] aberration, individually.--

Please substitute the following paragraph for the paragraph starting at page 6 line 9 and ending at line 27.

--Japanese Laid-Open Patent Application, Laid-Open No. 183190/1995, shows a projection exposure apparatus having an illumination optical system for illuminating a reticle and a projection optical system for projecting a pattern of the reticle, illuminated with the illumination optical system, onto a wafer at a predetermined reduction magnification. Optical means having a refracting power which is revolutionally asymmetrical with respect to an optical axis of the projection optical system, is disposed between the reticle and the wafer. This optical means is made rotatable about the optical axis of the projection optical system or it is made movable along the optical axis of the projection optical system, so as to correct any optical characteristic remaining in the projection optical system and being revolutionally asymmetrical with respect to the optical axis. However, on-axis coma [comma] aberration such as described above can not be corrected with this optical means.--

Please substitute the following paragraph for the paragraph starting at page 7, line 2 and ending at line 5.

--It is an object of the present invention to provide an optical system by which on-axis coma [comma] aberration or an aspect magnification error can be corrected.--

Please substitute the following paragraph for the paragraph starting at page 10, line 19 and ending at line 25.

--In accordance with an eighth [eights] aspect of the present invention, there is provided a projection system, comprising: a projection optical system; and an optical system according to the sixth or seventh aspect of the present invention, for correcting an aberration to be produced in said projection optical system.--

Please substitute the following paragraph for the paragraph starting at page 12, line 14 and ending at line 18.

--Figure 1 is a schematic view of an aberration adjusting optical system according to a first embodiment of the present invention, and it shows optical paths in a portion of a projection system having such an aberration adjusting optical system.

Please substitute the following paragraph for the paragraph starting at page 13, line 4 and ending at line 14.

--In Figure 1, the projection optical system 17 is telecentric on its image plane side, and the orientation of chief rays of imaging lights is parallel to an optical axis 14. A projection optical system of an exposure apparatus, for example, for use in the manufacture of semiconductor devices may preferably comprise such an optical system being telecentric on its exit side, to prevent a change in imaging magnification of a device pattern image, depending on the wafer surface position with respect to the optical axis direction.--

Please substitute the following paragraph for the paragraph starting at page 17, line 10 and ending at page 18, line 7.

--On the other hand, it will be readily understood that, even if the refracting power is sufficiently weak, not only the aspect magnification difference but also other aberrations such as a spherical aberration, which are influential to the imaging characteristic, are produced due to the aberration changing optical system 13. Therefore, it is necessary to design the projection optical system 17 while taking into account the influence of the aberration changing optical system 13. Further, in consideration of the property that the spherical aberration of the projection optical system 17 depends on the thickness of the aberration changing optical system 13, the spherical aberration of the projection optical system 17 as a product may be measured in practice and then a best thickness of the aberration changing optical system 13 may be determined. Further, the on-axis coma [comma] aberration of the projection optical system 17 may be measured and, on the basis of the result thereof, a best tilt angle of the aberration changing optical system 13 may be determined. Then, by tilting the aberration changing optical system 13 about an axis orthogonal to the optical axis, the on-axis coma [comma] aberration can be adjusted.--

Please substitute the following paragraph for the paragraph starting at page 20, line 12 and ending at line 16.

--With use of the aberration changing optical system of this embodiment, in addition to the aspect magnification error, other aberrations such as a spherical aberration, an on-axis coma [comma] aberration and an on-axis astigmatism, for example, can be adjusted.

Please substitute the following paragraph for the paragraph starting at page 20, line 17 and ending at page 21, line 3.

--More specifically, the aspect magnification error can be adjusted in accordance with the same principle as in the first embodiment. The spherical aberration can be adjusted by changing the central thickness of the two optical elements 311 and 312, by changing one by another. The on-axis astigmatism can be adjusted by rotating the aberration changing optical system 13 as a whole integrally, about the optical axis of the projection optical system, and by changing the tilt angles of the two optical elements 311 and 312 in opposite directions and by the same amount. Further, the on-axis coma [comma] aberration can be adjusted by tilting the aberration changing optical system 13 integrally.--

Please substitute the following paragraph for the paragraph starting at page 22, line 14 and ending at line 22.

--Figure 4 is a schematic view of a main portion of an aberration changing optical system according to a third embodiment of the present invention. In this embodiment, the

aberration changing optical system 13 comprises two optical elements 411 and 412 having the same refractive index and the same central thickness and being tilted with respect to the optical axis, in opposite directions and by the same angle.--

Please substitute the following paragraph for the paragraph starting at page 23, line 4 and ending at line 16.

--The aberration changing optical system 13 of this embodiment is provided with first rotating means for rotationally moving these two optical elements 411 and 412 about [an] axes perpendicular to their flat faces 411a and 412a, respectively, and first tilting means for changing the tilt angles of the two optical elements in opposite directions but by the same amount. Additionally, there are second rotating means for rotationally moving the whole aberration changing optical system 13 integrally, about the optical axis of the projection optical system, and second tilting means for tilting the whole aberration changing optical system integrally, in a desired direction.--

Please substitute the following paragraph for the paragraph starting at page 25, line 23 and ending at page 26, line 12.

--The angle defined between the direction in which the cylindrical surface 411b of the first optical element 411 has a curvature and the direction in which the cylindrical surface 412b of the second optical element 412 has a curvature, can be adjusted as desired. Here, the aspect magnification difference to be imparted by the aberration changing optical system varies

continuously from zero to a maximum. Thus, within a range from zero to an adjustable largest value, the aspect magnification difference in a desired amount and direction to be produced by the projection optical system can be adjusted through the aberration changing optical system of this embodiment. Further, like the second embodiment, the spherical aberration, the on-axis coma [comma] aberration and the on axis astigmatism of the projection optical system can be adjusted independently of each other, as desired.--

Please substitute the following paragraph for the paragraph starting at page 28, line 2 and ending at line 5.

--Figure 5 is a flow chart of a procedure for the manufacture of microdevices such as semiconductor chips ([e.g.] e.g., ICs or LSIs), liquid crystal panels, or CCDs, for example.--

Please substitute the following paragraph for the paragraph starting at page 28, line 6 and ending at line 23.

--Step 1 is a design process for designing a circuit of a semiconductor device. Step 2 is a process for making a mask on the basis of the circuit pattern design. Step 3 is a process for preparing a wafer by using a material such as silicon. Step 4 is a wafer process (called a pre-process) wherein, by using the so prepared mask and wafer, circuits are practically formed on the wafer through lithography. Step 5 subsequent to this is an assembling step (called a post-process) wherein the wafer having been processed by step 4 is formed into semiconductor chips. This step includes an assembling (dicing and bonding) process and a packaging (chip

sealing) process. Step 6 is an inspection step wherein an operation check, a durability check and so on for the semiconductor devices provided by step 5, are carried out. With these processes, semiconductor devices are completed and they are shipped (step 7).--

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO THE CLAIMS

1. (Amended) An aberration changing optical system for changing an aberration, said optical system comprising:

[characterized by] an optical element having at least one of a cylindrical surface and a toric surface, said optical element [surface and] being rotatable about and tiltable to an optical axis of said optical system.

2. (Amended) An aberration changing optical system for changing an aberration, said optical system comprising:

[characterized by] an optical element having different refracting powers in two orthogonal directions or having a refracting power only in one direction, said optical element being rotatable about and tiltable to an optical axis of said optical system.

3. (Amended) An aberration changing optical system according to Claim 1 or 2, further comprising [wherein there are] a plurality of optical elements each being rotatable and tiltable, [as aforesaid,] and wherein said optical elements are selectively used to change aberration.

4. (Amended) An aberration changing optical system according to Claim 1 or 2, further comprising [characterized by] a second optical element having at least one of a cylindrical surface and a toric surface, said optical element [surface and] being rotatable about and tiltable to

the optical axis of said optical system integrally with the first mentioned optical element, said second optical element further being tiltable in an opposite direction to the first-mentioned optical element.

5. (Amended) An aberration changing optical system according to Claim 1 or 2, further comprising [characterized by] a parallel flat plate being rotatable about and tiltable to said optical axis of said optical system integrally with the optical element, said parallel flat plate further being tiltable in an opposite direction to said optical element.

11. (Amended) An optical system for a projection exposure apparatus, said optical system comprising:

[characterized by] an optical element having at least one of a cylindrical surface and a toric surface, said optical element [surface and] being inclined with respect to an optical axis.

12. (Amended) An optical system for a projection exposure apparatus, said optical system comprising:

[characterized by] an optical element having different refracting powers in two orthogonal directions or having a refracting power only in one direction, said optical element being inclined with respect to an optical axis.

13. (Amended) An optical system according to Claim 11 or 12, further comprising [wherein there are] a plurality of optical elements each being rotatable and tiltable, [as aforesaid,] and wherein said optical elements are selectively used to change aberration.

14. (Amended) An optical system according to Claim 11 or 12, further comprising [characterized by] a second optical element having at least one of a cylindrical surface and a toric surface, said second optical element [surface and] being inclined with respect to the optical axis and in an opposite direction to the first-mentioned optical element.

15. (Amended) An optical system according to Claim 11 or 12, further comprising [characterized by] a parallel flat plate being inclined with respect to the optical axis and in an opposite direction to said optical element.